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MAPPING OF WILDLIFE HABITAT IN
FARMINGTON BAY, UTAH

CRSC Report 82-1



By

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ABSTRACT

This report describes the techniques and results of a project to map wildlife habitat in the Farmington Bay portion of the Great Salt Lake, Utah. Mapping was accomplished through the interpretation of high-altitude color infrared photography. The feasibility of utilizing Landsat digital data to augment the analysis was explored; complex patterns of wildlife habitat and confusion of spectral classes resulted in the decision to make limited use of Landsat data in the analysis.

The final product is a map which delineates wildlife habitat at a scale of 1:24,000. The map is registered to and printed on a screened U.S.G.S. quadrangle base map. Screened delineations of shoreline contours, mapped from a previous study, are also shown on the map. Intensive field checking of the map was accomplished for the Farmington Bay Waterfowl Management Area in August 1981; other areas on the map received only spot field checking.

INTRODUCTION

Farmington Bay, an arm of the Great Salt Lake lying east of Antelope Island, has been and continues to be a focal point of public interest. The area is primarily known for the state-owned and managed Farmington Bay Waterfowl Management Area (FBWMA). The FBWMA is a major source of habitat for migratory and resident waterfowl populations (Rawley and Johnson, 1978). It consists of a series of dikes behind which freshwater lakes and ponds have allowed a variety of plant communities to become established. Although most of the plants in the FBWMA must have above-average salt tolerance to survive, the habitat afforded by the successful vegetation offers a stark contrast to the inhospitable areas which are not protected from salt water intrusion by dikes or natural barriers.

Since the State of Utah's Division of Wildlife Resources is responsible for the enhancement of waterfowl and other wildlife populations in the FBWMA, there is a need for current management information. Knowledge as to the amount of waterfowl habitat available is needed to assist Division administrators in estimating population productivity and establishing hunting programs. Since the FBWMA is actively managed to provide a diversity of habitat for wildlife (e.g., redhead ducks, muskrats, other colonizing species), a spatial resource data base is needed to help evaluate development and management proposals. Such proposals range from Division plans to alter habitat, such as draining areas or removal of cattails, to proposals from private developers who have sought to alter conditions in Farmington Bay.

An additional concern is the effect of fluctuations in the elevation of the Great Salt Lake on the FBWMA and surrounding areas which do not have dikes. A previous study by the Center (Ridd, et al, 1981) produced maps of shoreline fluctuations for Farmington Bay. A study performed by the Utah Water Research Lab (James, et al, 1979) developed a model for estimating water surface elevation probabilities. The combination of the two studies cited above allows FBWMA administrators a means to assess the likelihood that a given area may be affected by lake level fluctuations.

The primary objective of this study has been to analyze and map the distribution of wildlife habitat in the FBWMA, and adjacent areas of Farmington Bay, from high-altitude color infrared photography. An additional objective has been to produce the wildlife habitat map at a scale to enable the shoreline fluctuation map, produced in a previous study, to be used as an overlay; this arrangement will facilitate the evaluation of the effects of variable lake levels on the amount and quality of available habitat. A final objective has been to explore the feasibility of using Landsat multi-spectral digital data to augment the analysis of aerial photography and mapping of wildlife habitat.

STUDY AREA

The study area includes the FBWMA and adjacent wildlife habitat areas located along the eastern shoreline of Farmington Bay. Figure 1 shows the six U.S.G.S. quadrangles which form the mapping base for the wildlife habitat map.

METHODS

Mapping Techniques

The primary medium for analysis and mapping was high-altitude color infrared aerial photography flown by NASA-Ames' U-2 plane on August 1, 1979. The photography is excellent quality and is cloud-free. Film positive transparencies at a scale of approximately 1:30,000 were utilized.

The first stage of map production was to interpret the mapping units which appear homogeneous within each unit and which have contrasting visual properties which may be detected on the photographs. Mapping units were identified by examining the following: the color, texture, and patterns on the photographs; hydrologic features; and topography.

The next stage of production was to delineate aerial photograph interpretations at the final map scale, which is 1:24,000, correct for photographic displacement, and register interpretations with the standard 7½ minute U.S.G.S. quadrangle base. This step was accomplished by use of a K&E Kargl cartographic projector, an enlarging light table; this technique allows the user to project the photograph or overlay onto a base map to make adjustments.

After interpretations were enlarged to the U.S.G.S. quad scale, preparations were made to expedite field checking to verify the interpretations and delineations in the study area. The delineations made on the base map

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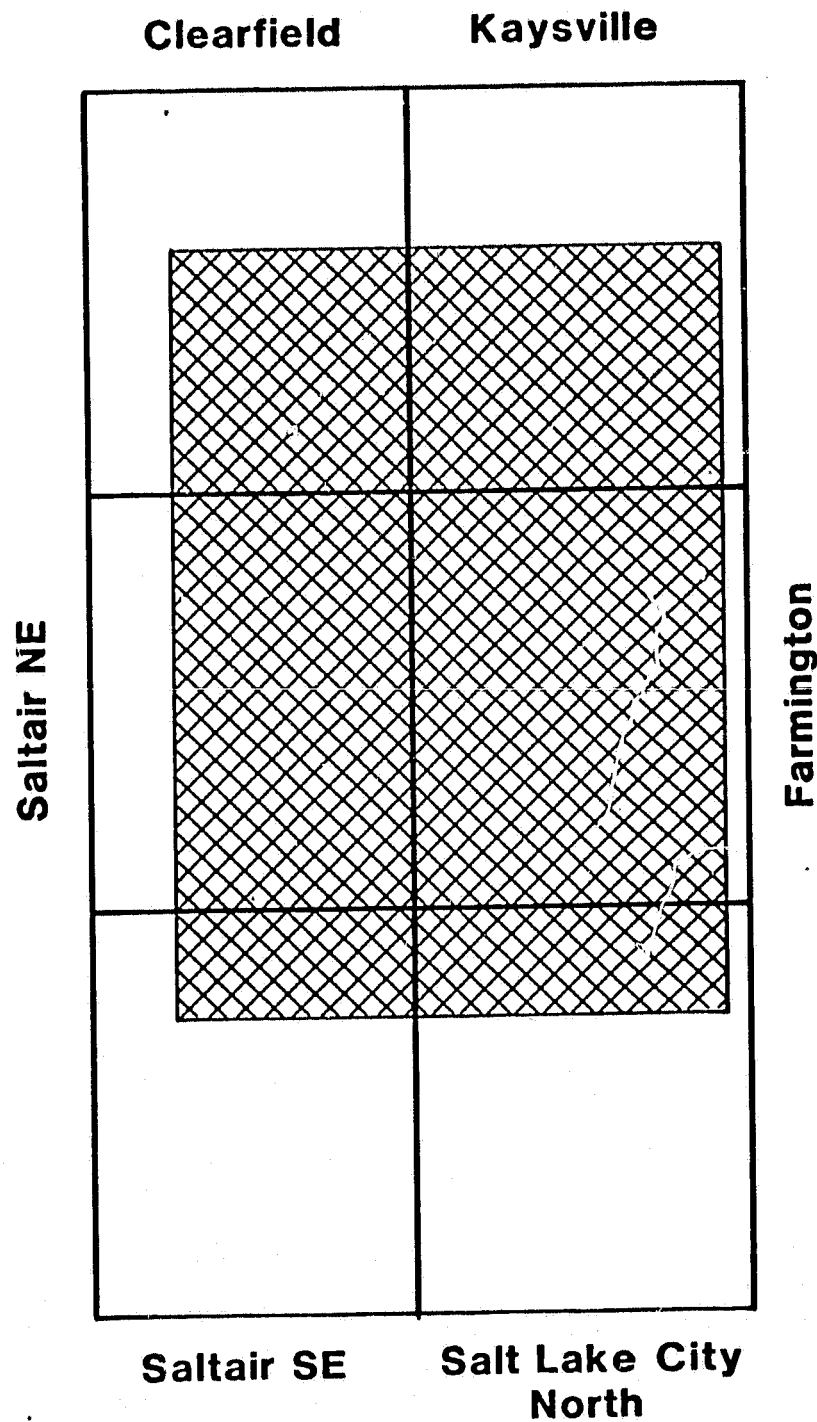


Figure 1. Location of the study area relative to the six U.S.G.S. 7½ minute quadrangles (scale 1:24,000). Cross-hatched area shows the boundaries of the Wildlife Habitat Map.

overlay were photographically reduced to match photo scale on transparent overlays. A photo mechanical transfer (PMT) process was used to accomplish this task. The PMT process is an efficient means to create a paper or transparency copy at an adjusted scale since the enlargement is accomplished in one step, whereas traditional processing requires a negative to be made first, from which the paper or transparency copy is developed.

Field checking the interpreted patterns on the photographs for the FBWMA was facilitated by the accessibility of that part of the study area. In September 1982, a couple of days spent in the field permitted rather thorough checking and labeling of features. Lack of access to wildlife habitat areas outside the FBWMA inhibited thorough checking. However, the photographic characteristics of such areas bore close resemblance to characteristics in the FBWMA, where field checking was easily accomplished. Landsat digital print map overlays, which are discussed below, assisted in labeling areas which were inaccessible.

Landsat Analysis

In addition to the application of photo-interpretive techniques, the Center examined the cost effectiveness of utilizing Landsat multi-spectral scanner ("MSS") digital data to augment photographic interpretations. Landsat digital tapes were purchased and analyzed to allow the same sort of merging of digital print maps with photos that proved helpful in a previous wetland/land use study in the Uinta Basin (Ridd, et al, 1980). The methods used to analyze the tapes are outlined below.

Initially, selected intense study areas (ISA) were located for the purpose of finding spectral signatures for land cover classification. A spectral signature is the mean reflectance in green, red, and two near-infrared bands

of light energy which is sensed by the Landsat MSS. Landsat records reflectance values for over 10 million picture elements or "pixels" in a given scene. The Landsat scene, or matrix of pixels for a ground area 115 miles by 115 miles, that was analyzed in this study was recorded on July 1, 1979.

After the digital data had been read into the computer and geographically corrected, a software package called "ELAS" was applied to analyze the data (see Stage 1 in Figure 2). Within ELAS there is a program entitled SEARCH, which is utilized to generate statistics that characterize pixel groups having similar spectral features across the four bands (see Stage 2 in Figure 2). SEARCH is a routine which is used to provide training statistics for a program called MAXL, which classifies individual pixels into groups based upon each pixel's highest statistical probability of belonging to a given group. In SEARCH, each contiguous six scan line (Landsat pixel matrix "row") by six element block (pixel matrix "column") is evaluated; if the spectral data within the six by six block is too heterogeneous, the program will switch to the use of a three by three block of pixels. The statistics generated by SEARCH include mean pixel light radiance values for each of the four bands, a covariance matrix, and a priori values. A set of statistics is generated by SEARCH representing various classes of light reflectance patterns found in the study area "searched". The four mean light reflectance values, one for each MSS band, are plotted to form a curve called a "light signature" which characterizes each class. SEARCH thus "trains" MAXL to recognize different ground cover patterns as it places individual pixels into classes. A knowledge of the manner in which different land cover features form spectral signatures, combined with the analysis of aerial photography and field checking of digital classifications, allows remote sensing researchers to provide an interpretation of Landsat-derived classes.

LANDSAT DIGITAL DATA ANALYSIS: STAGES 1 AND 2

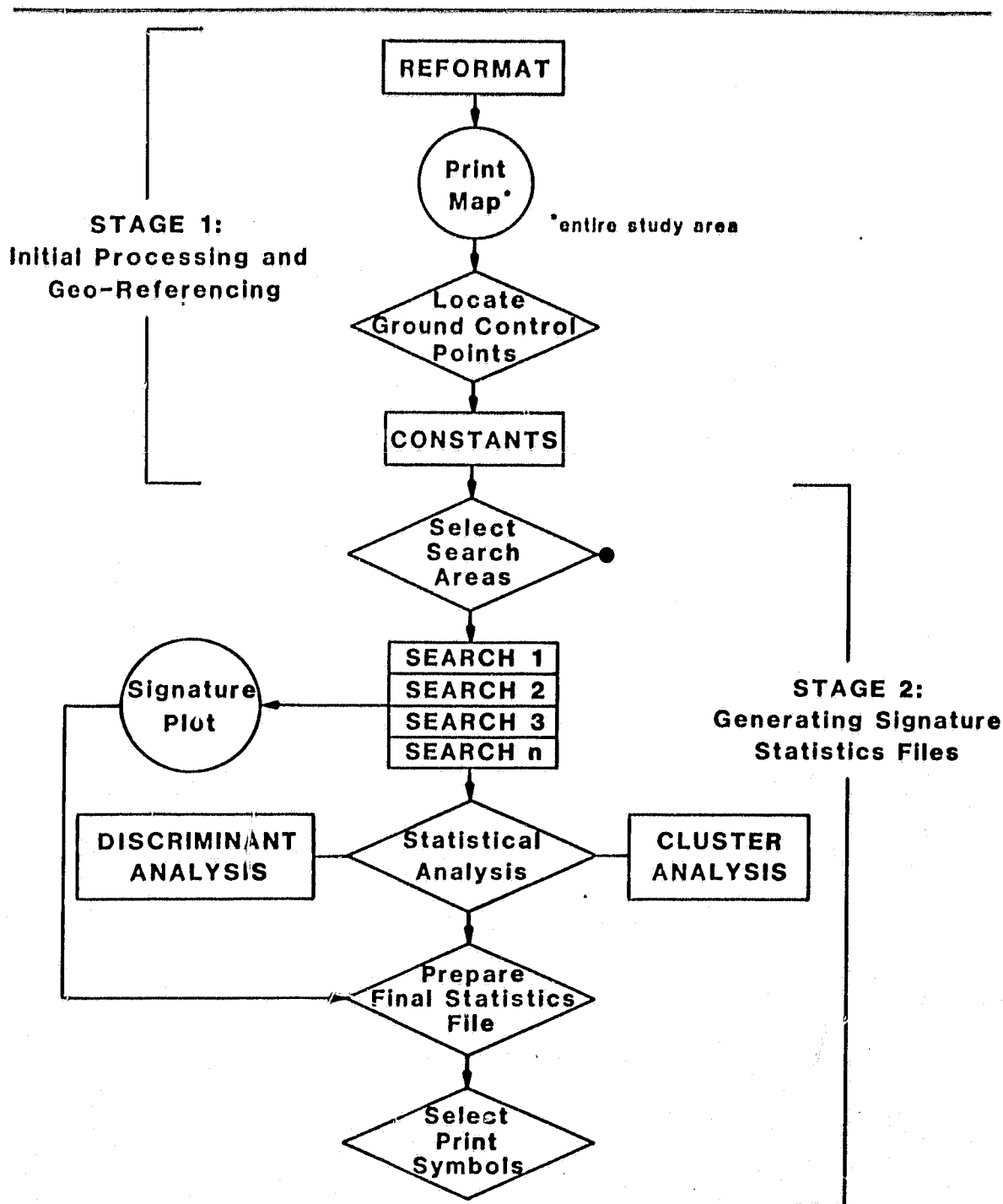
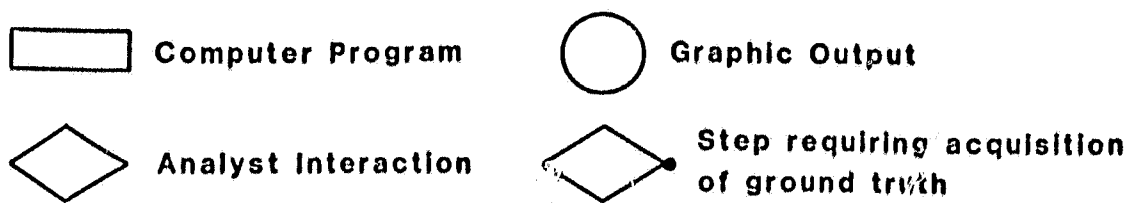


Figure 2. Summary of steps in Landsat digital data analysis: Stages 1 and 2.

In this study, 63 spectral signatures were derived from the SEARCH program. Experience has shown that spectral signatures often occur in families or groups which exhibit a high degree of similarity when pixels belonging to a given group are compared with "ground truth". Therefore, the next step is to reduce the number of symbols which appear on print maps by assigning signatures in a common group a common symbol. The decision to assign signature groups common symbols is accomplished through use of a combination of statistical routines and by generating print maps of selected areas and calibrating print symbols with ground observations (see Stage 2 in Figure 2, and Stage 3 in Figure 3). The statistical routines used at the Center include principal components, cluster analysis, and discriminant analysis. Application of the statistical analyses results to information gathered by comparing aerial photographs with light signature map print symbols allowed the combination of some signatures and further refinement of others.

RESULTS AND DISCUSSION

The results of interpreting the color infrared aerial photography and delineating vegetation features on the base map overlay is a 1:24,000 wildlife habitat map with two screened underlays. The first underlay map presents shoreline contours for the following elevations (mean sea level) of the Great Salt Lake: 4,198 ft.; 4,199 ft.; 4,200 ft.; 4,201 ft.; and 4,202 ft. A second base map, also screened to allow the principal map to stand out, is the mosaic of portions of the U.S.G.S. quadrangles registered to the map overlays.

The wildlife habitat map legend, shown in Figure 4, was developed through an interaction with administrators of the Utah Division of Wildlife Resources. Where single symbols are used to label areas, interpreters judged the cover

LANDSAT DIGITAL DATA ANALYSIS: STAGES 3 AND 4

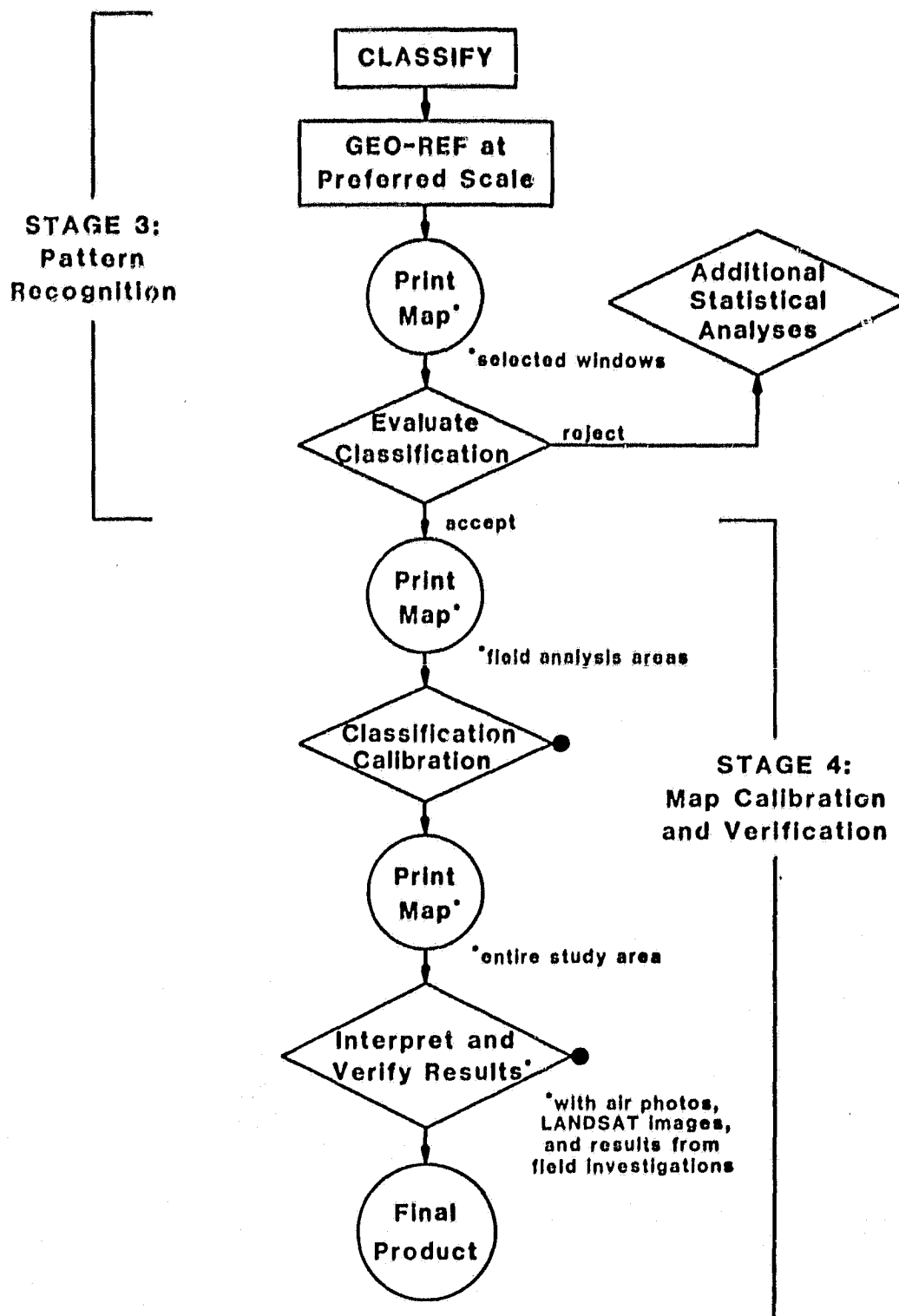





Figure 3. Summary of steps in Landsat digital data analysis: Stages 3 and 4.

LEGEND

WILDLIFE HABITAT

	W	Water	C	Cattail
	M	Mudflat, Wet	D	Sedge
	M	Mudflat, Dry	G	Saltgrass
	A	Wheatgrass	S	Salicornia
	B	Bulrush	T	Tree, Deciduous

Wildlife habitat was determined from color infrared photographs and field data.

GREAT SALT LAKE SHORELINES

ELEVATION (MSL)	DATE
4198 feet	30 Sept. 1972
4199 feet	2 July 1979
4200 feet	28 June 1978
4201 feet	13 Aug. 1976
4202 feet	24 May 1976

Shoreline positions were determined from computer processed NASA LANDSAT digital data of four spectral bands for each date.

Figure 4. Legend for the Wildlife Habitat Map for the eastern portion of Farmington Bay.

in such areas to have a uniformity of cover of 90 percent or greater. Where more than one symbol is used to label an area, such areas represent mixes, with the first symbol reflecting the cover type with 50 to 90 percent of the total cover, and the second symbol reflecting the majority of remaining cover types. This mapping convention was adopted since different types of vegetation in the study area often occurs in rather intricate patterns which, at the 1:24,000 mapping scale, are difficult to delineate and label without undue confusion to the map user. Detailed analysis of individual areas may be accomplished by reference to the aerial photographs.

The print maps produced from the Landsat digital data were analyzed as to their utility in augmenting the detailed mapping of habitat. Transparent overlays of print maps, photographically reduced to match photograph scale, were registered to several photographs in the FBWMA. From field experience, 89 test areas were selected on the photographs for which ground cover could be identified. Although a fair degree of consistency was observed between test areas of similar vegetation cover and corresponding print symbols, intricate patterns of contrasting vegetation types produced some confusion. That is, cover types with contrasting light reflectance such as cattail, saltgrass, water, and mud flat often occur in complexes which produce boundary pixels: pixels which straddle both cover types. Consequently, since much of the study area is quite accessible and the available photography is current and of excellent quality, reliance on photograph interpretation calibrated by field visits proved to be the most accurate and cost-effective means of mapping wildlife habitat. Also, the need for a high degree of map detail resulted in the need to emphasize field and photo work.

Since a certain amount of uncertainty accompanies any research effort, it is not always clear at the outset whether Landsat analysis will be a

cost-effective dimension of a study. However, experience in the FBWMA study area and other recent studies, has proved invaluable in terms of providing the Center the opportunity to explore the use of Landsat and develop some criteria which will help assure cost-effective use of Landsat in future projects. By asking a series of questions, and comparing the responses to our experience base (which includes vicarious experiences through others in the literature), we are provided with a means of selecting a study approach which will produce the desired final product. The primary questions are:

- Objective - What is to be studied and mapped?
- Purpose - Why is it to be mapped, how and by whom will the map be used?
- Resources - What maps, aerial photography, and imagery are available?
- Study Area - What is the size, topography, and nature, in terms of contrasts between surficial features, of the study area? How accessible are areas of special interest for purposes of facilitating field checking?
- Standards - What are the mapping accuracy standards, in terms of scale, legend categories, size of minimum mapping units, etc.?
- Limits - What are the practical limits to the project in terms of time, budget, and personnel?

Reflection upon the questions above, in light of an ever-increasing experience base with Utah environments, remote sensing media, and analytical techniques will do much to assure production of resource inventories meeting accuracy standards with minimum cost.

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